Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	
	)	
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
	)	
	)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
	)	
	)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
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Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

COMMENTS OF NOKIA

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COMMENTS OF NOKIA

Nokia respectfully submits comments in response to the Commission's Notice of Proposed Rulemaking ("*NPRM*")[1] seeking comment on specific spectrum bands above 24 GHz to promote the next generation of wireless.

[1] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, GN Docket Nos. 14-177 et al., Notice of Proposed Rulemaking (rel. Oct. 23, 2015) ("*NPRM*").

I. INTRODUCTION AND SUMMARY

The United States has been an early adopter in each generation of wireless technology, a major driver of innovation, and remains among the most vibrant wireless markets in the world. The U.S. has been a driver for the current generation of technology, Fourth Generation (4G) based on the Long-Term Evolution (LTE), and can continue to be a driving force in the next generation of wireless, Fifth Generation (5G) mobile services. This proceeding is an important step toward that goal. Nokia commends the Commission for proposing service rules for the millimeter wave (mmW) bands addressed in the *NPRM* that would encourage investment in 5G in the U.S. In particular, Nokia believes that the Commission should expedite the development of flexible rules for those frequencies.

As an active participant in earlier stages of this proceeding, including several presentations to Commission staff on a path forward for 5G, Nokia proposes in these Comments detailed guidance that Nokia believes would maximize the use of the mmW bands, foster innovation, and encourage investment. These comments begin by introducing a new era for Nokia, which recently combined forces with Alcatel-Lucent to create a single company with even further enhanced innovation capabilities. We are excited about this combination and how our combined strength will help facilitate the transition to the next generation of wireless.

Nokia then addresses a number of specific proposals within the *NPRM*.

Bands Under Consideration in the Proceeding. Nokia agrees with the Commission's four criteria that it used to prioritize bands above 24 GHz, including favoring: (1) wide-blocks of spectrum; (2) international harmonization; (3) compatibility with incumbent uses; and (4) a flexible regulatory framework that accommodates as wide a variety of services as possible.

These criteria should be considered important guidelines, not bright line rules, allowing deviation where appropriate.

Nokia further, strongly supports the Commission moving forward expeditiously to authorize mobile operations in the four bands identified in this proceeding: (1) the 27.5-28.35 GHz band (28 GHz band); (2) the 37.0-38.6 GHz band (37GHz band); (3) the 38.6-40 GHz band (39 GHz band); and (4) the 64-71 GHz band.

Nokia, however, is disappointed that the Commission omitted so many bands from this proceeding that were specified in the *Notice of Inquiry* ("*NOI*"),[2] including the 71-76 GHz and 81-86 GHz bands. Other bands such as 24.25-27.5GHz, immediately adjacent to the 28GHz band and part of the World Radiocommunication Conference of 2015 (WRC-15) bands, are also extremely important and worth extensive studies. Similarly, the range 24.25-29.5 GHz as a whole has great potential to become a global band for 5G and is worth extensive studies.

To best facilitate 5G, the Commission also should consider bands below 6 GHz and in the 6-24 GHz range. Nokia believes that the 3.7-4.2 GHz and 3.1-3.55 GHz could be particularly valuable as, as these bands would open up over 1 GHz of valuable spectrum when combined with 3.5GHz[3] (3.55-3.7 GHz). Another band of interest is the 1300-1390 MHz band.

In deciding the next bands for consideration, Nokia asserts that microwave backhaul is critical to the success of 5G, and therefore caution must be exercised when considering bands currently allocated for those services. That caution does not mean that these bands are not appropriate in all circumstances. For example, the 71-76 and 81-86 GHz bands contain

[2] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, GN Docket No. 14-177, Notice of Inquiry (rel. Oct. 17, 2014).
[3] *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, FCC 15-47, GN Docket No. 12-354, Report and Order and Second Further Notice of Proposed Rulemaking (rel. Apr. 21, 2015).

backhaul, but should be considered for mobile broadband under the appropriate regulatory framework (i.e., shared on a licensed basis).

Licensing Frameworks. In these comments, Nokia provides a number of recommendations with respect to licensing frameworks for the four bands considered in this proceeding. Specifically, Nokia recommends that the Commission adopt rules for the 28 GHz, 37 GHz, 39 GHz, and 64-71 GHz bands providing exclusive use licenses, with flexible use rights. The Commission should decline to adopt the overlay auction alternative that it proposed, as it would be cumbersome and problematic.

Similarly, the Commission should not adopt a "hybrid" licensing scheme, proposed for the 37 GHz band, which would grant operating rights by rule to property owners, while establishing geographic area licenses based on counties for outdoor use. Such a licensing framework would make the band unduly cumbersome for carriers to deploy, threatening the overall viability of the band. Moreover, such a hybrid scheme at 37 GHz would remove the potential benefits of aggregating the 37 GHz and 39 GHz band into a single 3 GHz of contiguous spectrum band.

Nokia urges the Commission to not adopt an unlicensed allocation for the entirety of the 64-71 GHz band. Rather, the Commission should authorize unlicensed operations in the 64-66 GHz band based on the rules adopted for the adjacent 57-64 GHz band, but license the 66-71 GHz band. Such unlicensed/licensed treatment has the promise of international harmonization, as the 66-71 GHz band was identified during WRC-15 for further study.

Nokia disagrees with the Commission's proposal for county-size geographic area licenses and proposes the following: Basic Trading Areas for the 28 GHz; and Economic Areas for the remaining bands considered in this proceeding (37 GHz, 39 GHz, and 66-71 GHz, if licensed).

With respect to license block size, Nokia advocates for blocks of at least 400 MHz in all of the bands and specifically for:

- 28 GHz: A single 850 MHz block or two blocks of 400 MHz and 450 MHz;
- 37 GHz: Four blocks of 400 MHz;
- 39 GHz: Two blocks of 500 MHz and one block of 400 MHz;
- For a combined 37 & 39 GHz bands (as proposed above): Six 500 MHz blocks;
- 66-71 GHz: Five 1 GHz blocks.

Nokia supports secondary market transactions and also pre-auction swaps, including with unauctioned blocks in the Commission's inventory, to enable large contiguous spectrum blocks.

Nokia supports a ten-year license term for the 28 GHz, 37 GHz, 39 GHz and 66-71 GHz licenses, with renewal expectancy. With respect to performance metrics, the Commission should not adopt its proposal for county-based, population metrics. It would be more appropriate to use performance metrics based on usage and/or service levels rather than census data. The Commission should also abandon the "Use-or-Share" obligation.

Nokia agrees that it is important to protect incumbents, but urges that the Commission limit coordination zones to the extent possible. The Commission should consider market-based rules instead of the Spectrum Access System to facilitate coexistence of satellite use of the 28 GHz, 37 GHz, and 39 GHz bands with 5G systems without unduly limiting and harming terrestrial use of those bands. Non-federal licensees should protect incumbent Federal operations, consistent with the Federal allocations in these bands.

Technical Rule Proposals. Nokia makes a number of technical rules recommendations to best unlock the potential of the bands proposed in this *NPRM*. Specifically, Nokia recommends:

- Flexibility for various duplexing options and not mandating Time Division Duplexing (TDD).

- Maximum EIRP for Base Stations: +55dBW (or +85dBm) for the 28 GHz, the 37GHz and 39 GHz bands, aligning Base Station transmit power with Part 101 rules.

- Maximum EIRP for mobile devices: + 43 dBm EIRP for mobile devices.

- A new category of devices (e.g., Customer Premise Equipment) which would have higher power limits (e.g., 53dBm) than mobile devices, but lower power limits than base stations, recognizing the need to study any relevant RF exposure issues.

- Out-of-Band Emission: -13dBm/100kHz for first one MHz bands immediately outside and adjacent to the licensee's frequency block and -13dBm/1MHz at 1MHz offset or larger from the block edge. (Should not use bandwidth dependence resolution bandwidth in first 1 MHz offset from the spectrum block edge.)

- Do *not* establish at this time field strength or power flux density limits at geographic service area borders of bands without incumbent licensees (e.g., 37 GHz and 66-71 GHz). In bands with incumbent licensees such as the 28GHz and 39GHz, existing operations could be protected by coordination amongst users.

- Clarification of interoperability requirements, as the current language is unclear and may lead to technical obligations that are impossible to meet.

- Consideration of IEEE C95.1-2005, as updated by IEEE C95.1a-2010, as the applicable RF exposure standard for the proposed bands and continue to study RF exposure issues related to mmW in the context of the Commission's other open proceeding (ET Docket Nos. 13-84, 03-137)[4] examining its RF exposure rules and policies. Guidance on how to demonstrate compliance with the Commission's exposure limits evaluation is to be issued by the FCC Laboratory.

II. NOKIA AND ALCATEL-LUCENT COMBINED TO CREATE AN INNOVATION LEADER IN NEXT GENERATION TECHNOLOGY AND SERVICES

Nokia's reputation as an innovation powerhouse has been bolstered by the addition of Alcatel-Lucent, creating unparalleled leadership in the technologies that connect people and

[4] *See Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields*, First Report and Order (RF Order) and Further Notice of Proposed Rule Making (RF Further Notice) and Notice of Inquiry (RF Inquiry), 28 FCC Rcd 3498 (2013).

things.[5] The combined company now possesses the capabilities and global scale to meet the extraordinary demands and opportunities of a world where everyone and everything is increasingly connected. Nokia is leveraging this strength to create a new type of network that is intelligent, efficient, and secure, and to advance the technologies that tap its power through smart devices and sensors. We are weaving together the networks, data, and device technologies to create the universal fabric of our connected lives. In this new paradigm, new applications will flow without constraint, services and industry will automate and run seamlessly, communities and businesses can rely on privacy, security, and near instant response times by connecting through the cloud.

The combination with Alcatel-Lucent brings together two high-performing companies to create a single portfolio, converging mobile broadband with fixed line access, and the underlying IP routing and optical technology that connects them. The combination also provides Nokia with highly complementary skills and geographic presences across the globe. Nokia's experience with 4G LTE, both its Frequency Division Duplex (FDD) and TDD versions, serves as the foundation for its 5G advocacy. Nokia has made pioneering advancements in reducing the footprint of mobile base station infrastructure, from compact yet full power macro sites down to the full range of "small cell" solutions, which are expected to be critical to 5G. Nokia also offers the industry's most comprehensive portfolio of services for integrating heterogeneous networks ("HetNets"), encompassing analysis, optimization, deployment, and management.

The combined company is uniquely positioned to create the foundation of seamless connectivity for people and things wherever they are. This foundation is essential for enabling

[5] *See* "Nokia and Alcatel-Lucent to Combine to Create an Innovation Leader in Next Generation Technology and Services for an IP Connected World," April 15, 2015, available at http://company.nokia.com/en/news/press-releases/2015/04/15/nokia-and-alcatel-lucent-to-combine-to-create-an-innovation-leader-in-next-generation-technology-and-services-for-an-ip-connected-world.

the next wave of technological change, including the Internet of Things and transition to the cloud. Following the combination, Nokia now has unparalleled innovation capabilities, with Bell Labs (headquartered in the United States), responsible for countless breakthroughs that have shaped the networking and communications industry, joining Nokia's FutureWorks and Nokia Technologies, which will stay as a separate entity with a clear focus on licensing and the incubation of new technologies. With approximately 40,000 employees performing research and development ("R&D") and a combined spend of approximately $4.5 Billion in 2014 on R&D,[6] Nokia is well placed to play a leading role in shaping the new revolution in connectivity, including the 5G technologies that are the subject of this proceeding.

As part of Nokia's 5G leadership, over the past year, we have provided technical resources to the Commission through several presentations and written submissions.[7] Nokia continues to offer the Commission its technical expertise, and commits to provide the Commission the information it needs to best position the United States for the next generation of wireless communications.

III. NOKIA SUPPORTS ADOPTING RULES FOR THE FOUR BANDS IDENTIFIED IN THIS PROCEEDING AND URGES THE COMMISSION TO COMMENCE PROCEEDINGS ON ADDITIONAL BANDS WITHOUT DELAY

A. Nokia Agrees with the Criteria Used by The Commission to Evaluate the Suitability of mmW bands, With Caveats

In this *NPRM*, the Commission relies on "four main criteria" for evaluating the suitability of mmW bands for mobile use. Specifically, the Commission determined that it would:

[6] This total excludes Nokia's HERE business, which was recently sold.

[7] *See, e.g.,* Comments of Nokia (d/b/a Nokia Solutions and Networks US LLC), GN Docket No 14-177, filed Jan. 15, 2015; Comments of Alcatel-Lucent, GN Docket No. 14-177, filed Jan 15, 2015; Comments of Nokia (d/b/a Nokia Solutions and Networks US LLC), GN Docket No 14-177, filed Feb 17, 2015; *Ex Parte* Presentation of Nokia (d/b/a Nokia Solutions and Networks US LLC), GN Docket No. 14-177, filed Aug. 26, 2015; *Ex Parte* Presentation of Alcatel-Lucent, GN Docket NO. 14-177, filed May 11, 2015.

1. focus on spectrum bands with at least 500 MHz of contiguous spectrum;

2. to the extent practicable, propose spectrum bands that are being considered internationally for mmW mobile service;

3. favor bands where mobile use in the mmW bands would be compatible with existing incumbent license assignments and uses; and

4. establish a regulatory framework that accommodates the widest possible variety of services.[8]

Nokia agrees that these criteria make sense for prioritizing bands above 24 GHz for this first proceeding. However, there are exceptions to each of the above. For example, the Commissions should not arbitrarily exclude bands in the future simply because the bands do not contain at least 500MHz of spectrum since certain applications and use cases of 5G may still be feasible for smaller carrier bandwidths. While the *NPRM* specifies this criterion to apply specifically to mmW bands, considering narrower blocks of spectrum is especially important in lower frequency bands where such wide spans of fallow spectrum may not exist. As another example, Nokia overwhelmingly favors international harmonization as a means to achieve the overall benefits of larger economies of scale and wide-spread development. However, lack of global consensus on a band at this stage should not block the Commission from considering that band. The 28 GHz band is a prime example of a band where the Commission should continue moving forward to support technological advancements as the band shows great promise for 5G.

B. Nokia Strongly Urges the Commission to Move Forward with the Four Bands, Including 28GHz

Using the four criteria discussed above, the Commission identified four bands that Nokia agrees show great promise for the next generation of wireless. The Commission chose to focus on the following bands above 24 GHz: (1) 27.5-28.35 GHz; (2) 38.6-40 GHz; (3) 37-38.6 GHz;

[8] *NPRM* ¶¶ 20-23.

and (4) 64-71 GHz. Nokia also appreciates that the Commission made these recommendations in advance of, and to inform discussions at, World Radio Conference of 2015 (WRC-15) for which bands should be studied by the ITU for World Radio Conference of 2019 (WRC-19). Nokia strongly urges the Commission to move forward with the four proposed bands, including the 28 GHz band, which ultimately was not identified at WRC-15 to be studied in ITU towards WRC-19.

Nokia believes that the 28 GHz band holds great potential as expressed by the support offered by countries like the U.S., Korea, Japan, Finland, Sweden, Columbia, Singapore and Slovenia at WRC-15. As the United States stated at WRC-15:

> The United States, supported by Colombia, Finland, Japan, Korea, Singapore, Slovenia and Sweden, express concerns with the discussions and disposition of the future conference agenda item to study spectrum for next generation mobile services (5G) using bands above 6 GHz. Mobile broadband is the highest growth sector in the telecommunications industry worldwide and it is crucial that the ITU address the needs of countries worldwide. Certain bands proposed by regional groups and individual countries for study under this agenda item were removed from consideration despite this support.
>
> The ITU must continue to be a place that promotes and enables new technologies. Opposition even to studies in the band range 27.5-29.5 GHz is inconsistent with the ITU's role as an organization for international consultation and indicates a loss of faith in the study process and a preference for the status quo. The evaluation of innovative sharing techniques to create new opportunities is paramount to accommodate technological advances that will benefit the global economy. Given the pace of technological innovation and the demand for mobile broadband services, the ITU could lose its relevance if it does not join in a meaningful way in the search for globally harmonized spectrum for IMT-2020.

Nokia is disappointed with the outcome of WRC-15 with respect to the 28 GHz band and urges the Commission to continue its efforts to unlock the promise of that band for the United States.

C. Nokia Encourages the Commission to Consider Additional Bands in More Detail, and to Account for Microwave Backhaul Needs as It Does So

a. A Number of Bands Above 24 GHz Identified in the NOI and WRC-15 Were Regretfully Omitted from the *NPRM* and Should be Expeditiously Considered in a Future *NPRM*

There are a number of bands, which the *NOI* discusses, but for which the *NPRM* declines to propose service rules, including: (1) 24.25-24.45 GHz and 25.05-25.25 GHz; (2) 29.1-29.25 GHz and 31-31.3 GHz; (3) 31.8-33 GHz; (4) 42-42.5 GHz; (5) 71-76 GHz and 81-86 GHz; and (6) above 86 GHz.

While the Commission determined it would initially focus on only four bands in this *NPRM*, it also indicates that it would consider other bands in a subsequent proceeding as it continues to build a record on those bands, including compatibility issues, and as technology develops.[9] In particular, the Commission mentions that the outcome of the WRC-15 (which occurred in November 2015, after the release of the *NPRM*), could influence the Commission to address some of these other bands at a later date. The Commission recognizes in the *NPRM*,

> [O]ther countries have proposed or will propose the identification of other bands for consideration for mobile broadband. We are committed to working with both domestic and international partners in examining additional spectrum and on conducting the necessary technical sharing and compatibility studies. To the extent it becomes appropriate to consider additional bands for mmW mobile use in light of international developments, we will work with relevant stakeholders to examine the suitability of those bands for mobile and other uses.[10]

At WRC-15, the United States supported the Inter-American Telecommunications Commission (CITEL) proposal to consider spectrum requirements and identification of bands for the terrestrial component of International Mobile Telecommunications (IMT) to facilitate mobile broadband applications. The goal in WRC-15 was to identify possible spectrum for mobile use

[9] *See NPRM ¶ 3.*
[10] *Id.* ¶ 14.

to be considered at WRC of 2019 (WRC-19). The CITEL proposal resolves to conduct sharing and compatibility studies, including adjacent band studies as appropriate, within the frequency ranges: 10-10.45 GHz, 23.15-23.6 GHz, 24.25-27.5 GHz, 27.5-29.5 GHz, 31.8-33 GHz, 37-40.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz and 59.3-76 GHz. Proposals by CITEL, other regional bodies and administrations were discussed at WRC-15. The outcome was an agreement for a new agenda item for 5G spectrum at WRC-19 and to conduct and complete in time for WRC-19 the appropriate sharing and compatibility studies for the following frequency bands:

- 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz, which have allocations to the mobile service on a primary basis; and
- 31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz, which may require additional allocations to the mobile service on a primary basis.[11]

Nokia would have liked for these bands to be under consideration in the current *NPRM*. However, we appreciate the recognition in the *NPRM* that the fact that a particular band or bands are not considered in this *NPRM* does not foreclose future Commission action on the band or bands. We also agree with Commissioner Pai's and Commissioner O'Rielly's respective statements indicating that the *NPRM* does not provide a persuasive reason for omitting them from consideration in this proceeding.[12]

Based on the foregoing, Nokia urges the Commission to expeditiously commence a further rulemaking on additional bands. The 71-76 GHz and 81-86 GHz bands in particular should be priority bands for a future proceeding, as they were already identified in the *NOI*, were part of the WRC-15 bands and even satisfy the Commission's criteria used to select bands for

[11] RESOLUTION COM6/20 (WRC-15) of Provisional Final Acts World Radiocommunication Conference (WRC-15)," available at http://www.itu.int/pub/R-ACT-WRC.11-2015/en

[12] *See NPRM*, Statement of Commissioner Ajit Pai, Approving in Part and Dissenting in Part; *id*. Statement of Commissioner Michael O'Rielly, Approving in Part, Dissenting in Part.

further study. Other bands such as 24.25-27.5 GHz, immediately adjacent to the 28 GHz band and part of the WRC-15 bands, are also extremely important and worth extensive studies. Similarly, the range 24.25-29.5 GHz as a whole has great potential to become a global band for 5G and is worth extensive studies.

b. Bands Below 24 GHz Also Are Critical to the Next Generation of Wireless

While mmW bands are critical components of 5G, the next generation of wireless will demand spectrum at all ranges: high, middle and low. To that end, Nokia is working with various partners worldwide to develop 5G technology in mmW bands as well as in the centimeter range (3-30 GHz), both below and above 6 GHz.[13] We urge the Commission to study bands such as the 24 GHz band (24.25-27.5 GHz) as well as bands below 6 GHz such as the 3.7-4.2 GHz or 3.1-3.55 GHz identified as potential bands for commercial broadband services by the Commission's Technological Advisory Council (TAC) Advanced Sharing Task Group.[14] When combined with 3.5 GHz (3.55-3.7 GHz), this could open 1.1 GHz of contiguous spectrum below 6 GHz that would provide "substantial amount of contiguous bandwidth in order to enable 5G services."[15]

Other bands of interest include the 1300-1390 MHz band. Just like the action by the Commission on the Spectrum Frontiers TAC[16] led to the *NOI* and the *NPRM*, Nokia urges the Commission to act on the recommendations from the TAC Advanced Sharing Task Group to

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[13] Nokia Networks explores potential of 5G below 6 GHz frequencies with NTT DOCOMO - See more at: http://networks.nokia.com/news-events/press-room/press-releases/nokia-networks-explores-potential-of-5g-below-6-ghz-frequencies-with-ntt-docomo#sthash.mdpKlK7a.dpuf; 5G Millimeter Wave Proof of Concept : Cooperation Between Nokia and NTT DOCOMO- See more at: https://www.youtube.com/watch?v=EGYkQ5KdKMk; World-first: 5G cmWave Technology – 19.1 Gbps throughput - See more at: http://networks.nokia.com/videos/world-first-nokia-5g-cm-wave-technology-19-1-gbps-over-the-air.

[14] Technical Advisory Council, Advanced Sharing and EWT WG, September 23, 2014, available at https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting92314/September23rd-TAC-Full-Presentation-R1.pdf.

[15] *NPRM* ¶ 16.

[16] *See NOI* ¶ 14; *NPRM* ¶ 7.

unlock more spectrum below 6 GHz for mobile broadband services.

c. The Commission Should Account for Microwave Backhaul when Promoting 5G Spectrum

While Nokia supports the study of other bands, we note that the use of bands that are currently used for microwave backhaul needs to be cautiously considered. These bands are used to provide backhaul for existing and future mobile systems. As such, they are essential for the delivery of mobile broadband. Otherwise, the Commission could inadvertently create a bottleneck for the very mobile broadband traffic it seeks to accommodate with the new spectrum.

That caution does not mean that these bands are not appropriate in all circumstances for 5G. For example, Nokia considers the 71-76 and 81-86 GHz bands of future interest for 5G under the appropriate regulatory framework (i.e., shared on a licensed basis) even though it contains backhaul. Nokia respectfully submits that sharing between microwave backhaul and mobile broadband access in these bands should be feasible. Sound engineering design and deployment could mitigate interference between backhaul and mobile systems. As the Commission recognizes in the *NPRM*, "in-band backhaul might be feasible in the mmW bands by dedicating a certain portion of array antennas of 5G system for backhaul use or allocating certain portion of timeslots of TDD 5G system for backhaul use."[17] Such techniques would facilitate the coexistence of backhaul and mobile systems the same band in the future.

IV. THE COMMISSION SHOULD ADOPT RULES FOR THE 28 GHZ, 37 GHZ, 39 GHZ, AND 64-71 GHZ BANDS CONSISTENT WITH THE PROVEN EXCLUSIVE USE, FLEXIBLE RIGHTS MODEL

The Commission correctly recognizes in the *NPRM* that, "[t]echnological advances holds promise in unlocking the potential of using mmW bands for mobile uses in a way that meets the

[17] *NPRM* ¶ 276.

need for flexible access to spectrum to improve bandwidth in constrained geographies."[18] To that end, Nokia fully agrees with the Commission's goal "to develop flexible rules that will accommodate a wide variety of current and future technologies."[19] The proposed mmW bands should indeed be licensed with flexible rights to provide both fixed and mobile services in a geographic area.

A. The Commission Should Grant Flexible Rights Licenses and Decline to Adopt the Overlay Auction Proposal

Nokia supports the Commission's proposal to grant flexible fixed and mobile use rights to existing licensees in 28 GHz and 39 GHz bands and auction "dormant" licenses and licenses returned to the Commission under similar flexible rules instead of utilizing an overlay auction as an alternative. The benefits of such a flexible use approach are well-recognized and set forth by the Commission in the *NPRM*:

- This approach will minimize transaction costs and provide the fastest transition to expanded use of the band, which would be to the benefit of consumers.
- Attempting to define separate bundles of "fixed" and "mobile" rights might create unnecessary complexity and be inconsistent with the underlying technologies, in which case it would be more efficient to have both the fixed and mobile usage rights contained within the same license.
- The existence of separate licenses for fixed and mobile operation might create unusually large challenges related to interference.[20]

The idea of an "overlay auction" that would award an overlay right to new licensees subject to non-interference with incumbents is not favored. An overlay auction could result in interference issues among existing and new licensees using the same spectrum block in a given location. Dealing with such interference issues could needlessly delay the deployment of 5G as

[18] *Id.* ¶ 5.
[19] *Id.* ¶ 3.

more complex use cases emerge that will require 5G deployment sooner rather than later.

The commercial mobile market has blossomed under a framework of access to exclusively licensed spectrum. This paradigm has driven the deployment of robust 4G broadband networks across the country. Continuing to identify additional spectrum for exclusive licensing, including in the mmW bands, must remain the top objective for government spectrum decision-makers.

B. The Commission Should Decline to Adopt the Hybrid Licensing Proposal For 37 GHz and, Instead, Adopt the Same Approach as For 39 GHz Band

The Commission proposed that the 37 GHz band would be licensed via a hybrid approach that would convey "local area" operating rights to premises' occupants by rule, and separately, geographic area licenses for wide area use. Nokia opposes the hybrid approach. Rather, substantial benefits could be realized by taking similar approaches across the proposed mmW bands. Aggregating the adjacent 37 GHz and 39 GHz bands under a single consistent licensing framework would provide 3 GHz of contiguous spectrum that could be leveraged to provide 5G services using large blocks of spectrum. Further arguing against the hybrid scheme, the proposed partitioning of the spectrum under the hybrid approach would make it be difficult for licensees with outdoor and indoor business plans to invest. Imposing a novel hybrid licensing scheme as proposed by the Commission would add uncertainty, significantly undercutting the attractiveness of the band for carrier investment and creation of demand necessary to create a device ecosystem.

In addition, RF coexistence between local and wide area deployments could become an issue. Conversely, while the imposition of a hybrid licensing scheme would likely stunt the growth of the 37 GHz band, the Commission's goal of promoting new in-building services could very well thrive without such a licensing scheme. To the extent such services are technically

viable and attractive to property owners, such property owners could seek the spectrum rights they would require in the secondary markets.

C. The Commission Should Allocate the 64-71 GHz Band for Licensed Use, at least in part

The Commission proposes to authorize unlicensed operations in the 64-71 GHz band under Part 15 of their rules based on the rules they recently adopted for the adjacent 57-64 GHz band. While Nokia supports the allocation of additional spectrum for unlicensed services, we note that the Commission's proposal would result in a vast imbalance in the amount of unlicensed and licensed spectrum considered in this *NPRM*: 14 GHz of allocated for unlicensed operations (from 51-71 GHz) versus only 3.85 GHz allocated for licensed operations (28 GHz, 37 GHz and 39 GHz). The amounts of licensed spectrum and unlicensed spectrum should be more balanced.

Our concerns are bolstered by the fact that the Commission's plans for unlicensed operations go against the goal of international harmonization. The 66-71 GHz band is among the bands to be studied in ITU towards WRC-19, and has the potential to become a true globally harmonized licensed band, which is one of the benchmark criteria suggested by the Commission. Spectrum harmonization promotes economies of scale and enables global roaming, which reduces equipment design complexity and to improves spectrum efficiency.[21] All of this ultimately reduces costs for consumers. Device costs are a significant issue, and widely supported spectrum bands and channels can lower the crucial component costs. Harmonization also aids in addressing cross border coordination.

In sum, Nokia respectfully suggests that the Commission allocates 66-71 GHz to licensed

[21] *See* Document 5D/246-E, Canada's input to ITU-R WP 5D, "Technical perspective on benefits of spectrum harmonization for mobile services and IMT," 23 January 2013.

services and 64-66 GHz to unlicensed services to further international harmonization, which would still provide an indisputably generous amount of unlicensed spectrum for consideration in this proceeding.

D. The Commission Should Choose Geographic Licensing Areas Larger than Counties for the 28, 37 and 39 GHz Bands

The Commission proposes to use counties as the base geographic area for licenses in the 28, 39, and 37 GHz bands and seeks comment on alternative geographic area sizes. Instead of county-sized geographic area licenses, Nokia recommends that the Commission retain the current larger geographic areas for mobile service, namely, Basic Trading Areas in 28 GHz and Economic Areas in 39 GHz. In addition, the Commission should adopt Economic Areas in 37 GHz as in 39 GHz since these two bands are immediately adjacent to each other and can provide 3 GHz of contiguous spectrum under the same rules.

As noted above, Nokia also urges the Commission to license the 66-71 GHz band. Nokia recommends use of Economic Areas as the geographic licensed size in that band, to be consistent with the approach that should be taken for licensed spectrum in the 37 and 39 GHz bands.

If the current geographic areas are used, as we propose, existing licensees would not be required to obtain new licenses if they want to deploy mobile services, and interference between new licensees and existing ones would be easier to manage. Nokia further asserts that larger geographic areas would provide higher certainty for investment in advanced mobile services in these mmW bands because this will provide the flexibility to the operators to deploy infrastructure where it is needed. It will also be an administrative burden to manage county-wide licenses traded in secondary markets. As a final matter, 5G use cases such as communications for vehicles, telemedicine, smart grids and smart cities are all use cases that may span several

counties.[22] For all of these reasons, larger-than county areas would better facilitate successful deployment of these bands.

E. The Commission Should Adopt a Ten-Year License Term with Renewal Expectancy and Consider Alternative Performance Metrics

Nokia supports a ten-year license term for the 28 GHz, 37 GHz, 39 GHz, and 66-71 GHz licenses. We agree with the Commission that this would be "the most seamless, consistent and expedient path"[23] for licensing these bands. Nokia also agrees with the Commission's proposal that, "licensees should receive a renewal expectancy for subsequent license terms if they continue to provide at least the level of service required at the end of their initial license terms through the end of any subsequent license terms."[24] This is consistent with other mobile bands.

The Commission proposes performance requirements applied at the county level. The Commission further suggests that a population coverage metric may be the most logical, with a licensee potentially required to cover 40 percent of the population in a county by the end of the license term, and that failure to meet the performance requirement would cause the license to terminate automatically.

Nokia disagrees with these proposals. As noted above, we believe the licenses should be assigned with greater than county-level geographic scope. Nokia also does not agree with the proposed metrics described above, and respectfully submits that the flaws in those metrics would be exacerbated by the proposed undersized geographic scope the *NPRM* appears to favor. It would be more appropriate to use performance metrics based on usage and/or service levels rather than census data. Indeed, as the Commission pointed out the challenges of population

[22] Nokia, 5G Use Cases And Requirements (2014), available at http://networks.nokia.com/sites/default/files/document/5g_requirements_white_paper.pdf.
[23] *NPRM* ¶ 121.
[24] *Id.* ¶ 122.

based metrics for 5G, when it asks: "To the extent systems are used primarily at businesses, is there any way to reliably measure the daytime population within an area? If a system is used to serve an area with a heavy tourist or transient population, is it possible and appropriate to measure those types of populations?"[25]

Whatever metrics the Commission chooses, the performance metrics need to be flexible, reflecting the diversity of 5G applications. For example, a more appropriate performance metric might be number of transmitters in service, number of connected devices, carried traffic, etc. We encourage the Commission to consider alternative approaches while recognizing that they may need to revisit the metric in the future based on lessons learned from deployments.

Nokia has great concerns with the Commission's "use it or share it" proposal. Specifically, the Commission proposes "that portions of a license area that remain unused after 5 years after the initial license is issued, or, for incumbent licensees, five years after the effective date of the new rules, be made available for shared use by other users."[26] Nokia opposes this approach because it is envisioned that deployments in these bands will be cutting edge, developing technologies. Interested parties may be discouraged to buy access to the spectrum if they may be asked to share it. Licensees who have met the level of service required should not be required to share their spectrum, or risk needing to clear recalcitrant users that continue to operate despite the rightful licensee commencing deployment.

V. THE COMMISSION SHOULD ALLOCATE SPECTRUM BLOCKS OF AT LEAST 400MHZ IN THE 28GHZ, 37GHZ AND 39GHZ BANDS AND BLOCKS OF AT LEAST 1GHZ IN 66-71GHZ

The Commission rightfully notes in the *NPRM*:

[25] *NPRM* ¶ 208.
[26] *Id.* ¶ 215.

> [S] ignificant momentum was starting to build among diverse countries and regions around the idea of a fifth generation of mobile and fixed services, that some envision as accommodating an eventual 1000-fold increase in traffic demand for mobile services; high-bandwidth content with speeds in excess of 10 gigabits per second (GB/s); end-to-end transmission delays (latency) of less than one-thousandth of a second, and, in the same networks, sporadic, low-data-rate transmissions among an "Internet of things"—all of this to be accomplished with substantially improved spectral and energy efficiency.[27]

The channel bandwidth used by the 5G systems will impact some of the requirements referenced above, especially the data rates.

It is envisioned that a band will be made available in spectrum blocks which can then hold multiple 5G carriers. The Commission proposes band plans as follows (1) a single 850 MHz block for the 28 GHz band; (2) retaining the existing 50 MHz channel pairs for the 39 GHz band; and (3) four 400 MHz blocks for the 400 MHz band.

Nokia respectfully disagrees, and submits the following alternative proposal. As an initial matter, Nokia recommends that the Commission abandon the existing band plan for the 39 GHz band consisting of 14 channel pairs (50 MHz channels paired with 50 MHz channels) since the channel size is too small to allow the existing and new licensees to fully take advantage of the spectrum.

Further, as a result of a study Nokia conducted, described in Appendix A to these Comments, Nokia instead recommends the following band plans for all bands considered in this *NPRM*:

- 28 GHz: A single 850MHz block or two blocks of 400MHz and 450MHz;
- 37 GHz: Four blocks of 400MHz;
- 39 GHz: Two blocks of 500MHz and one block of 400MHz;
- For a combined 37 & 39 GHz bands (as proposed above: six 500MHz blocks;

[27] *Id.* ¶ 7.

- 66-71 GHz: Five 1GHz blocks.

In Appendix A, system level simulation results are provided to show the impact on user equipment (UE) throughput performance at 39 GHz that results from increasing the system bandwidth under certain deployment assumptions. 200 MHz, 400 MHz and 800 MHz channel bandwidths were considered. The results show that whether UEs were indoors or outdoors, significant increases in UE throughput can be achieved with higher system bandwidths, as shown in Tables 1-4 below.

Based on the results of the studies, Nokia proposes that the Commission establish spectrum blocks of at least 400 MHz in the 28 GHz, 37 GHz and 39 GHz bands. While a block of 800 MHz would provide even higher throughput, it would result in a lower number of licensees. We recognize that smaller blocks like 200 MHz could be combined to provide larger channel bandwidths to meet the targeted 5G data rates. However, it is not guaranteed that a given operator will obtain contiguous blocks of spectrum.

In case non-contiguous blocks are obtained, non-contiguous carrier aggregation would need to be used and one practical issue associated with carrier aggregation is the increase of the Peak-to-Average Power Ratio (PAPR). High PAPR signals would require a large range of dynamic linearity from the circuits, which could result in expensive devices, and higher power consumption/lower efficiency (for example, power amplifier has to operate with larger backoff to maintain linearity) with possible impact on range and system performance. While solutions can be developed to solve any resulting technical issues, these could add more complexity and cost to the system design. On the other hand, allocating larger blocks would increase the chance of an operator not having to use carrier aggregation for example. We therefore suggest that 400 MHz blocks would provide the right balance between the number of operators in the 28 GHz, 37 GHz and 39 GHz bands and the possibility to meet the 5G data rates without having to make the

systems more complex than needed.

Channel Bandwidth	200MHz	400MHz	800MHz
Throughput (Mbps)	123	246	495

Table 1: Downlink Mean UE throughput performance: 100% Indoor UEs (half with low penetration loss, half with high penetration loss), BS: 62dBm/100MHz EIRP.

Channel Bandwidth	200MHz	400MHz	800MHz
Throughput (Mbps)	96	173	312

Table 2: Uplink Mean and 5th percentile UE throughput performance: 100% Indoor UEs (half with low penetration loss, half with high penetration loss), UE: 43 dBm EIRP.

Channel Bandwidth	200MHz	400MHz	800MHz
Throughput (Mbps)	214	430	855

Table 3: Downlink Mean UE throughput performance: 100% Outdoor UEs (zero penetration loss), BS: 62dBm/100MHz EIRP. [28]

Channel Bandwidth	200MHz	400MHz	800MHz
Throughput (Mbps)	187	367	725

Table 4: Uplink Mean UE throughput performance: 100% Outdoor UEs (zero penetration loss), UE: 43 dBm EIRP. [29]

In its comments to the Commission on the *NOI*, Nokia presented similar results for a 5G system at 70 GHz, assuming a channel bandwidth of 2 GHz and concluded that "very high average user throughputs of between 2.07 Gbps to 5.12 Gbps are obtained in all layouts" that

[28] The UE power was assumed to be 43dBm irrespective of the bandwidth and explains why the throughput did not exactly scale with the bandwidth.

were studied.[30] Therefore, in the 66-71 GHz band, where an even larger swath of spectrum is available, we recommend spectrum blocks of at least 1GHz wide.

Nokia also supports secondary market transactions and also pre-auction swaps, including between license holders and with unauctioned spectrum in the Commission's inventory, to enable large contiguous spectrum blocks to be auctioned and also made available to existing licensees.

VI. FSS LICENSEES CAN ELIMINATE INTERFERENCE CONCERNS BY ACQUIRING TERRESTRIAL RIGHTS; FEDERAL OPERATIONS SHOULD BE PROTECTED WHILE MINIMIZING SIZES OF COORDINATION ZONES

Nokia recommends that the Commission consider market-based rules and coordination techniques instead of the Spectrum Access System and other measures proposed to facilitate coexistence of satellite use of the 28 GHz, 37 GHz, and 39 GHz bands with 5G systems without unduly limiting and harming terrestrial use of those bands.[31] Nokia supports the Commission's proposal for FSS licensees to remove any concerns accompanying secondary status for FSS in the 28 GHz band, by permitting FSS licensees to acquire terrestrial rights with primary status. The FSS operator could do so by acquiring its own terrestrial license at auction or through secondary market arrangements with another entity that obtains a terrestrial license.

Nokia does not believe that changes to treatment of gateway earth station applications and ubiquitous deployment of Space-to-Earth user equipment in 37.5-40 GHz is warranted. Providing satellite operators with information about terrestrial stations in order for those satellite operators to adapt their UE deployment plans to take into consideration the presence of interference generated by terrestrial stations also seems to be a burdensome approach. This

[30] See Comments of Nokia, GN Docket No. 4-177, Section II, sub-section 1.3, filed Jan. 15, 2015.
[31] *See NPRM* ¶¶ 150-159.

information can also be too sensitive for terrestrial operators to share. Before the Commission allows satellite operators to increase the intensity of their Power Flux Densities (PFDs) above existing limits, the interference impact to terrestrial systems needs to be thoroughly assessed.

Nokia agrees with the Commission that non-Federal licensees should protect incumbent Federal operations, consistent with the Federal allocations in these bands. The Commission should continue work with NTIA and other Federal agencies to minimize Federal coordination zones, which would maximize the value of the spectrum.

VII. TECHNICAL RULES

Nokia hereby provides various technical inputs to support the Commission's goal to "develop a flexible set of rules that will authorize as wide a variety of services as possible and avoid mandating specific technologies or deployment models."[32]

A. Flexible Duplexing Rules

In Nokia's experience, current 5G proposals or demonstrations predominantly use spectrum above 24 GHz based on TDD and not FDD. Some inherent advantages of TDD are less complex radios, the ability to use dynamic TDD, and obtaining more accurate Channel State Information (CSI) for transmit beamforming with lower overhead.

"Dynamic" TDD means that each different base station can optimize its uplink/downlink split for the traffic in its cell and not coordinate across base stations. In addition, it is possible also to share the dynamic TDD link between access and backhaul traffic to allow for efficient in-band backhaul links. The more noise-limited behavior of mmW systems enables dynamic TDD since little interference is seen between cells. The use of dynamic TDD enables a more efficient use of the spectrum (e.g., unused uplink resources can be reused for the downlink) than both

[32] See *id.* ¶ *266.*

FDD and "normal" TDD. More accurate CSI is possible through channel reciprocity (i.e., the uplink RF channel is the same as the downlink RF channel) and appropriate array calibration. For example, to obtain CSI for downlink beamforming the mobile station only needs to sound its antennas on the uplink. However, while TDD is a good candidate for 5G mmW systems, the Commission should not mandate TDD for mmW systems, but should leave the door open to FDD and other new types of duplexing that may be available in the future.

B. Transmission Power Limits

a. Base Station (BS)

Nokia supports the Commission's proposal to maintain the transmit power of fixed point-to-point and point-to-multipoint systems at + 85dBm EIRP and proposes to align the transmit power of "mmW mobile Base Stations" to + 85dBm EIRP instead of Commission's proposed 62dBm/100MHz EIRP level. This would align BS transmit power with Part 101 rules allowing a maximum EIRP of +55dBW (or +85dBm) for the 28 GHz, the 37GHz and 39 GHz bands.

This would also align with the Commission's modified Part 15 rules in 57-64 GHz "to provide transmitters located outdoors with very high gain antennas (i.e., higher than 30 dBi) an average EIRP emission limit of 82 dBm and a peak EIRP limit of 85 dBm, in each case minus 2 dB for every dB that the antenna gain is below 51 dBi.[33]

Nokia recommends that the proposed 85 dBm EIRP for BS should also apply to 66-71 GHz band if it is licensed. Increasing the transmit power of BS to align with the point-to-point systems also provides flexibility to provide "in-band" backhaul.

In Appendix A, system level simulation results are provided to show the impact on UE throughput performance at 39 GHz that results from increasing the BS transmit power from the

[33] 47 C.F.R. § 15.255(b)(1)(ii).

Commission's proposed 62 dBm/100 MHz EIRP to 85 dBm EIRP. The simulation results show that for indoor UEs, the deployment under consideration was path loss limited due to the high penetration losses at 39GHz. As a result, increasing the transmit power levels can significantly improve system performance.

For example, the mean UE throughput with 100% of Indoor UEs (half with low penetration loss, half with high penetration loss) increases from 246 Mbps to 377 Mbps with a 400 MHz channel bandwidth. For outdoor UEs, the deployment under consideration was heavily interference limited, as shown by the fact that increasing the transmit power led to no significant improvement in system performance (mean UE throughput of around 430 Mbps for a BS EIRP of 62 dBm/100 MHz EIRP versus 437 Mbps for a BS EIRP of 85 dBm, with 100% of Outdoor UEs and 400 MHz channel bandwidth for both cases).

b. User Equipment (UE)

Nokia supports the Commission's proposal to promulgate a + 43 dBm EIRP for mobile UEs. However, Nokia also supports the addition of a new category of UEs (e.g., Customer Premise Equipment) which would have higher power limits (e.g., 53 dBm) than mobile devices but lower power limits than base stations, recognizing the need to study any relevant RF exposure issues.

In Appendix A, system level simulation results are provided to show the impact on UE throughput performance at 39 GHz that results from increasing the UE transmit power from the Commission's proposed +43 dBm EIRP to + 53 dBm EIRP. The simulation results show that for indoor UEs, the deployment under consideration was path loss limited due to the high penetration losses at 39 GHz. As a result, increasing the transmit power levels can significantly improve system performance.

For example, the mean UE throughput with 100% of Indoor UEs (half with low penetration loss, half with high penetration loss) increases from 173 Mbps to 237 Mbps with a 400 MHz channel bandwidth. For outdoor UEs, the deployment under consideration was heavily interference limited, as shown by the fact that increasing the transmit power led to no significant improvement in system performance (mean UE throughput of 367 Mbps for a UE EIRP of 43 dBm versus 373Mbps for a UE EIRP of 53 dBm, with 100% of Outdoor UEs and 400 MHz channel bandwidth in both cases).

C. Emission Limits

The Commission proposes the following emission limits:

(a) The power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in EIRP by at least 43 + 10 log10 (P) dB.

(b) (1) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.[34]

The Commission's proposed attenuation of 43+10log(P), which translates to -13dBm, for emissions should be appropriate since it should be feasible to obtain such levels while ensuring coexistence with other systems in adjacent channels. However, the Commission should not use bandwidth-dependent resolution bandwidth in first 1MHz offset from the spectrum block edge. Instead, Nokia recommends emission limits of -13 dBm/100 kHz for the first one MHz bands immediately outside and adjacent to the licensee's frequency block and -13 dBm/1 MHz at 1MHz offset or larger from the block edge.

[34] *NPRM*, Appendix A, § 30.203 Emission Limits.

D. Coordination and Field Strength Limits at Market Borders

Phased array systems with beams steered to each user will help mitigate overall harmful interference between licensees in adjacent geographic areas using the same frequency bands. Therefore, Nokia believes that at this stage there is no need to establish field strength limits at the boundaries of license areas of bands without incumbent licensees, like the 37 GHz and 66-71 GHz bands, to prevent harmful interference. Coexistence between licensees could be managed by coordination and technology without the Commission regulating field strength limits at market borders in these bands. As experience is gained with deployments, such limits could be introduced later if needed. In bands with incumbent licensees, such as the 28 GHz and 39 GHz bands, existing operations can be protected by coordination amongst users.

E. Interoperability

The Commission proposes "to require that mobile equipment operating within each mmW band be interoperable using all air interfaces that the equipment utilizes on the frequencies. Interoperability helps ensure a robust market for equipment, and helps ensure that such equipment is available equally to all licensees."[35] While Nokia agrees with the Commission that interoperability is a feature that would support a robust 5G ecosystem, we ask that the Commission clarify that they did not intend that equipment is expected to utilize an air interface on all the frequencies that it supports. For example, it should not be mandated that an air interface supported in the mmW bands should be supported in a band below 6 GHz and vice versa if the equipment operates in both bands. Instead, we agree with the interpretation that "Mobile and portable stations that operate on any portion of frequencies within the 27.5-28.35 GHz or the 37-40 GHz bands must be capable of operating on all frequencies within those

[35] *NPRM* ¶ 296.

particular bands using the same air interfaces that the equipment utilizes on any frequencies in the 27.5-28.35 GHz or the 37-40 GHz bands, respectively."[36]

F. Equipment Authorization

a. Measurement Techniques

Nokia agrees with the Commission that "direct measurement of the fundamental EIRP of millimeter-wave devices including those that use dynamic beamforming antenna arrays across channel bandwidths of 100 MHz (or more) at millimeter-wave frequencies are more challenging than the present guidance for a number of reasons."[37] For example, the millimeter-wave devices being contemplated are expected to be designed with an array of multiple antennas employing dynamic beamforming and no output port for which to measure the conducted power of the transmitter, which may make challenging the verification of transmitter power, EIRP, and antenna gain.[38]

At this stage, Nokia does have any further data to provide to the Commission, and suggests that the Commission rely on the FCC Laboratory guidance which does offer a procedure to measure the out-of-band and spurious emissions from devices with multiple antennas.

b. RF Exposure Compliance

Nokia encourages the Commission not to delay the availability of this valuable spectrum while waiting for RF exposure issues to be addressed in the context of the Commission's other open proceeding (ET Docket Nos. 13-84, 03-137)[39] examining its RF exposure rules and

[36] *See NPRM*, Appendix A, § 30.209 Interoperability.
[37] *NPRM* ¶ 319.
[38] *See id.* ¶ 318.
[39] *See Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields*, ET

policies. Instead, the Nokia encourages the Commission to consider IEEE C95.1-2005, as updated by IEEE C95.1a-2010, as the applicable RF exposure standard for the proposed bands.

VIII. CONCLUSION

Nokia welcomes this *NPRM* to explore the use of spectrum above 24 GHz, as detailed above. The availability of huge bandwidth coupled with the use of large antenna arrays at both the transmitter and receiver can make this spectrum attractive for deploying high capacity 5G networks. Nokia recommends that the Commission expedite the development of flexible rules for the proposed bands. These Comments provide several inputs on the technical rules relevant to the use of bands above 24 GHz for mobile services as well as Nokia's views of the service rules that would be necessary to facilitate mobile use of those bands.

While we applaud the Commission for exploring new spectrum above 24 GHz to expand mobile broadband connectivity to consumers across the nation, we urge the Commission not to exclude other bands, both below 6 GHz and from 6-100 GHz that may become relevant for 5G, especially if there is potential for harmonization with other parts of the world based on the outcome of WRC-15. In particular, we recommend that the Commission reconsiders other bands listed in the *NOI* like the 71-76GHz and 81-86GHz bands. Other bands such as 24.25-27.5GHz, immediately adjacent to the 28GHz band and part of the WRC-15 bands are also extremely important and worth extensive studies. Similarly, the range 24.25-29.5 GHz as a whole has great potential to become a global band for 5G and is worth extensive studies. We also encourage the Commission to explore new spectrum from 6 GHz to 24 GHz and not just above 24 GHz. Below 6 GHz, some of the bands the Commission should explore include 3.7-4.2 GHz

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Docket Nos. 13-84, 03-137, First Report and Order (RF Order) and Further Notice of Proposed Rule Making (RF Further Notice) and Notice of Inquiry (RF Inquiry), 28 FCC Rcd 3498 (2013).

and 3.1-3.55 GHz. When combined with 3.5 GHz (3.55-3.7GHz), this could open 1.1 GHz of contiguous spectrum below 6 GHz. Others bands of interest include the 1300-1390 MHz band. While Nokia supports the study of other bands, we also note that the use of bands that are currently used for microwave backhaul needs to be cautiously considered.

Nokia looks forward to continuing to work with the Commission and our industry partners to make new spectrum available as we transition toward the next generation of wireless.

Respectfully submitted,

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APPENDIX A: SIMULATIONS AND CAPACITY RESULTS

A. Introduction and Overview

This section describes the result of a system simulation study performed to evaluate the throughput characteristics of the 5G system under particular deployment scenarios. Other scenarios can provide different results. The simulation study looked at the performance of a suburban residential deployment of base stations (BSs) configured to provide broadband wireless access within a 100-300m radius. The focus of the study is to evaluate the impact of system bandwidth and transmit power on the overall user throughput performance in a residential 5G wireless system operating at 39 GHz.

In the following section (Section B), this Appendix reviews the deployment scenario and system assumptions. Section C presents UE throughput performance results for three UE deployment cases that were simulated. Section D examines the statistics of two key metrics (CDF of the received Signal-to-Noise-Ratio (SINR) at the output of the receive antenna processing at the UE and CDF of the per-UE throughput) that are helpful for understanding the performance characteristics of the 5G system. Section E presents the Conclusions of this 5G system capacity simulation study.

B. Deployment Scenario and System Assumptions

Figure 1 shows the deployment scenario considered for the simulation study. The deployment consisted of a neighborhood of houses and roads arranged in a 2 block by 8 block layout. Each neighborhood block consists of 20 houses arranged with 10 houses on each side of a road. The base station is positioned at a height of 6m (below roof-top) in the positions shown in Figure 1. For the purposes of computing path loss, the User Equipment (UE) for a house is assumed to be located on the side of the house facing the base station located on its street. As

shown in Figure 1, for the layout considered, the distance between BSs located on the same y coordinates are 85m, while the distance between BSs located on the same x coordinates are 280m. The simulation procedure followed the methodology in [4], which leveraged a 3GPP-RAN Working Group 1-compliant system level simulator with modifications appropriate for the deployment scenario. The system parameters assumed in the simulation are summarized here:

Line-of-sight and blockage modeling: Each UE was determined to be either line of sight or non-line of sight based on the following procedure. Given the locations of the UEs and BSs, it was first determined whether a house blocked the line-of-sight path between each UE and each BS. If a house blocked the path between a UE and a BS, then that link is assumed to be NLOS. If a house does not block the path between a UE and an BS, then the distance-dependent random blocking model used in [4] was used to determine if an object in the environment (e.g., a car, tree, etc.) blocks the line-of-sight path. If an object is determined to block the line-of-sight path, then the link is determined to be NLOS, otherwise the link will be LOS (assuming no house blocked the line-of-sight path).

Path loss modeling: the close-in-reference distance path loss model is used to determine the path loss for each radio link in the system. The parameters of the path loss model at 39GHz are shown in Table 1. The path loss values for LOS links (not blocked by a house or a random object in the environment) are computed based on the LOS parameters, while the path loss values for NLOS links (blocked by either a house or a random object in the environment) are computed based on the NLOS parameters.

Penetration Loss Modeling: For UEs that are considered to be located indoors, an additional penetration loss value was added to the path loss computed in the previous step to represent the penetration loss from outdoor-to-indoor (and indoor-to-outdoor) propagation.

Multipath model: For a 39 GHz deployment, the multipath fading model used in the simulations was the 3D mmW UMI channel model from [3].

System Parameters for 39GHz: a Null Cyclic Prefix Single Carrier (NCP-SC) system was modeled at 39 GHz, and the parameters for 200, 400, and 800 MHz bandwidths are listed in Table 2. Parameters of the Base stations and the UEs are listed in

Table 3 and Table 4 respectively.

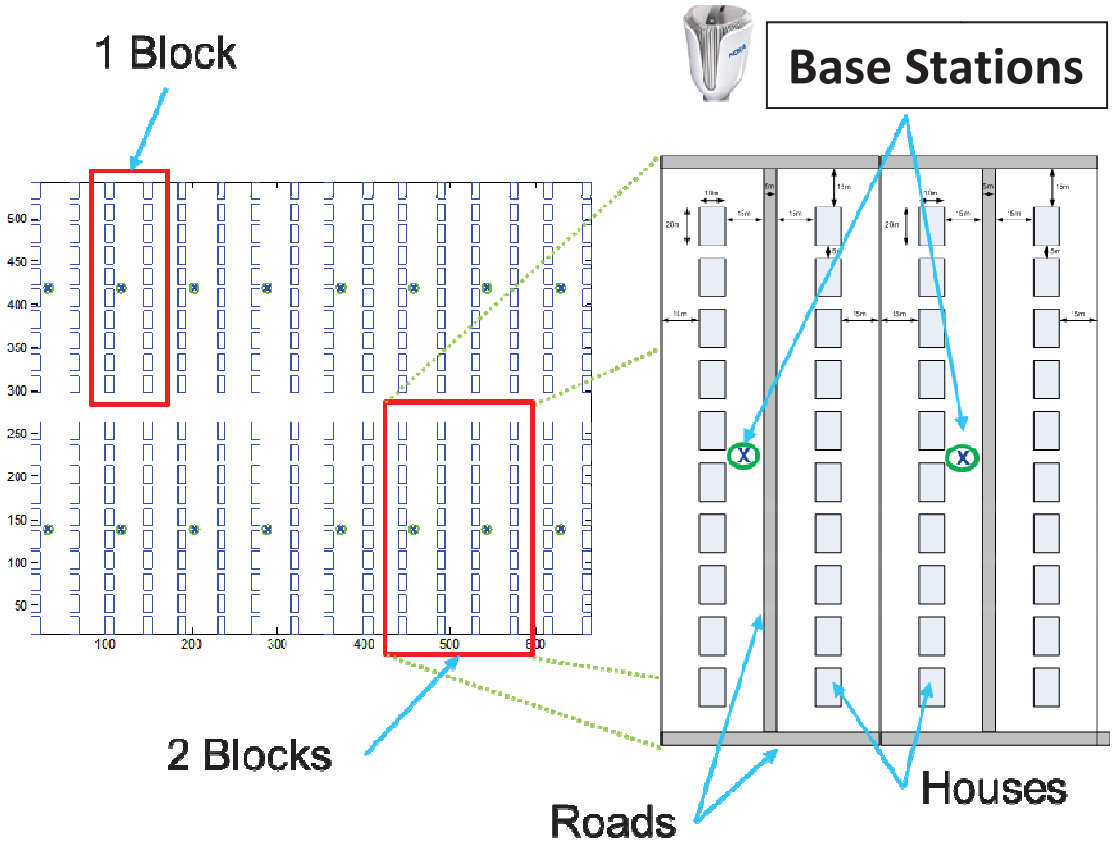

Figure 1 – Example Deployment scenario for 5G simulation study

Table 1 Propagation Parameters at 39 GHz

Propagation Modeling Parameters	**Value (39 GHz)**
Reference Distance	1m
Path Loss Exponent (LOS)	1.98
Path Loss Exponent (NLOS)	3.13
Shadow Fading (LOS)	3.1
Shadow Fading (NLOS)	8.93
Penetration Loss (Low-Loss) (dB)	15 dB
Penetration Loss (high-Loss) (dB)	36 dB
Blocking Model	Statistical [4]
Multipath Fading Model	mmW-UMi [3]

Table 2 NCP-SC System Parameters (39 GHz)

NCP-SC Parameter	**Value (200 MHz)**	**Value (400 MHz)**	**Value (800 MHz)**
Operating Band	39 GHz	39 GHz	39 GHz
Nominal Bandwidth	200 MHz	400 MHz	800 MHz
Roll-off Factor	0.25	0.25	0.25
FFT Size	256	512	1024
Subcarrier Spacing (kHz)	600	600	600
Null-to-Null Bandwidth (MHz)	192	384	768
Tsample (nsec)	6.5	3.3	1.6
NCP Duration (nsec)	46	48	50.5
NCP Overhead	2.7%	2.9%	3.0%

TTI duration (sec)	0.0001	0.0001	0.0001
Duplexing	TDD	TDD	TDD
TDD Split	50-50	50-50	50-50
Link Adaptation Table	LTE	LTE	LTE
Resource overhead from control/pilots, (not including NCP overhead)	20%	20%	20%
Peak per-UE theoretical throughput (max rank=2)	0.661 Gbps	1.322 Gbps	2.645 Gbps

Table 3 Base station Parameters (39 GHz)

Base station Parameters [39 GHz]	**Value**
Number of Sectors per Site	3
BS TX EIRP (dBm)	62dBm per 100MHz or 85dBm
BS Noise Figure (dB)	5
BS Antenna Array Options (3-Sector BS) per sector	XP2D: 8 rows by 4 columns by 2 pol (64 antennas)
BS Antenna Element Beamwidth (3-Sector) (degrees)	60, azimuth and elevation
BS Array downtilt (degrees)	3
BS Height (m)	6
Traffic Model, etc.	Full Buffer with HARQ
DL TX method	Wideband Eigenbeamforming based on ideal sounding reference signals (SRS)
SU-MIMO: Max Rank per UE	2
Channel Estimation Error Model	Ideal

Table 4 UE Parameters (39 GHz)

UE Parameters	Value
UE Antenna Array options	XP-ULA (omni), 2 antennas
UE Transmit EIRP (dBm)	43dBm or 53dBm
UE Noise Figure (dB)	9
Percent of UEs that are indoors	100% or 0%
Percent of Indoor UEs that have high penetration loss rather than low penetration loss	50% or 0%
UE Height (m)	1.5

C. Performance Evaluation at 39 GHz with 200/400/800 MHz Bandwidth

For a NCP-SC system operating at 39GHz with bandwidths of 200, 400 and 800MHz, simulation results are provided for three UE deployment cases listed here where the phrase in brackets is the label used on the plots showing the simulation results:

- [indoor50] All UEs are indoors, where 50% of the UEs have the high penetration loss value, and 50% of the UEs have the low penetration loss value
- [indoor00] All UEs are indoors, and all UEs have the low penetration loss value.
- [Outdoor] All UEs are outdoors (all UEs have zero penetration loss)

For the Base Stations, two values for the max EIRP were considered: 62dBm per 100MHz or 85dBm. For the UEs, two transmit power levels were considered: 43dBm and 53dBm. The base station sites had three sectors with a 64-antenna 2D array of cross pol elements in each sector. The transmission scheme was SU-MIMO with a maximum transmission rank of 2. The UEs had 2-cross-pol omni antennas. The parameters followed Table 1 through Table 4.

Figure 2 & Figure 3 show the mean and 5th percentile (cell edge) UE throughput performance for the case with all UEs located indoors, where half the UEs had the low penetration loss value for 39GHz, while the other half had the high penetration loss value for 39GHz. Figure 2 is for the downlink, and Figure 3 is for the uplink.

Figure 4 & Figure 5 show the mean and 5th percentile (cell edge) UE throughput performance for the case with all UEs located indoors, where all of the UEs had the low penetration loss value for 39GHz. Figure 4 is for the downlink, and Figure 5 is for the uplink.

Figure 6 & Figure 7 show the mean and 5th percentile (cell edge) UE throughput performance for the case with all UEs located indoors, where all of the UEs had the low penetration loss value for 39GHz. Figure 6 is for the downlink, and Figure 7 is for the uplink.

Several observations and conclusions can be made regarding the system at 39GHz:

- With UEs deployed indoors at 39GHz with a 50-50 mix of high-low penetration loss, the low EIRP choice resulted in a system with cell edge (5th percentile) rates at or near zero.
- For indoor UEs, increasing the transmit power and the bandwidth can significantly improve the throughput performance. With indoor UEs in the deployment being studied and the two transmit powers considered, the system is clearly path loss limited (as opposed to interference limited) since increasing the transmit power resulted in significant performance improvements.
- For outdoor UEs, increasing the bandwidth can significantly improve the throughput performance, but there is virtually no performance difference between the two transmit power levels. With outdoor UEs in the deployment being studied and the two transmit powers considered, the system is clearly limited by interference since increasing the transmit

power resulted in no improvement in system performance.

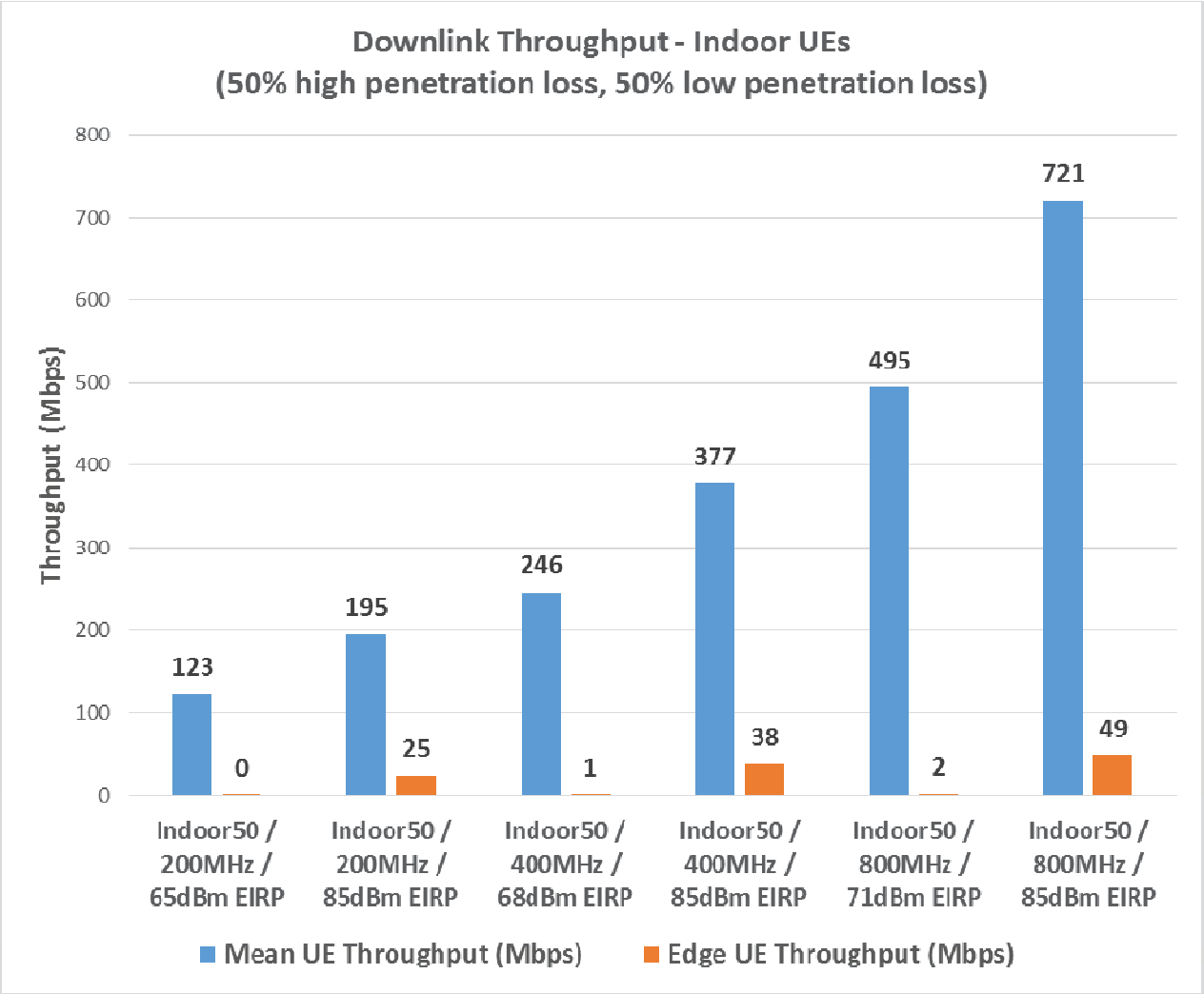

Figure 2 – Downlink Mean and 5th percentile UE throughput performance: 100% Indoor UEs (half with low penetration loss, half with high penetration loss).

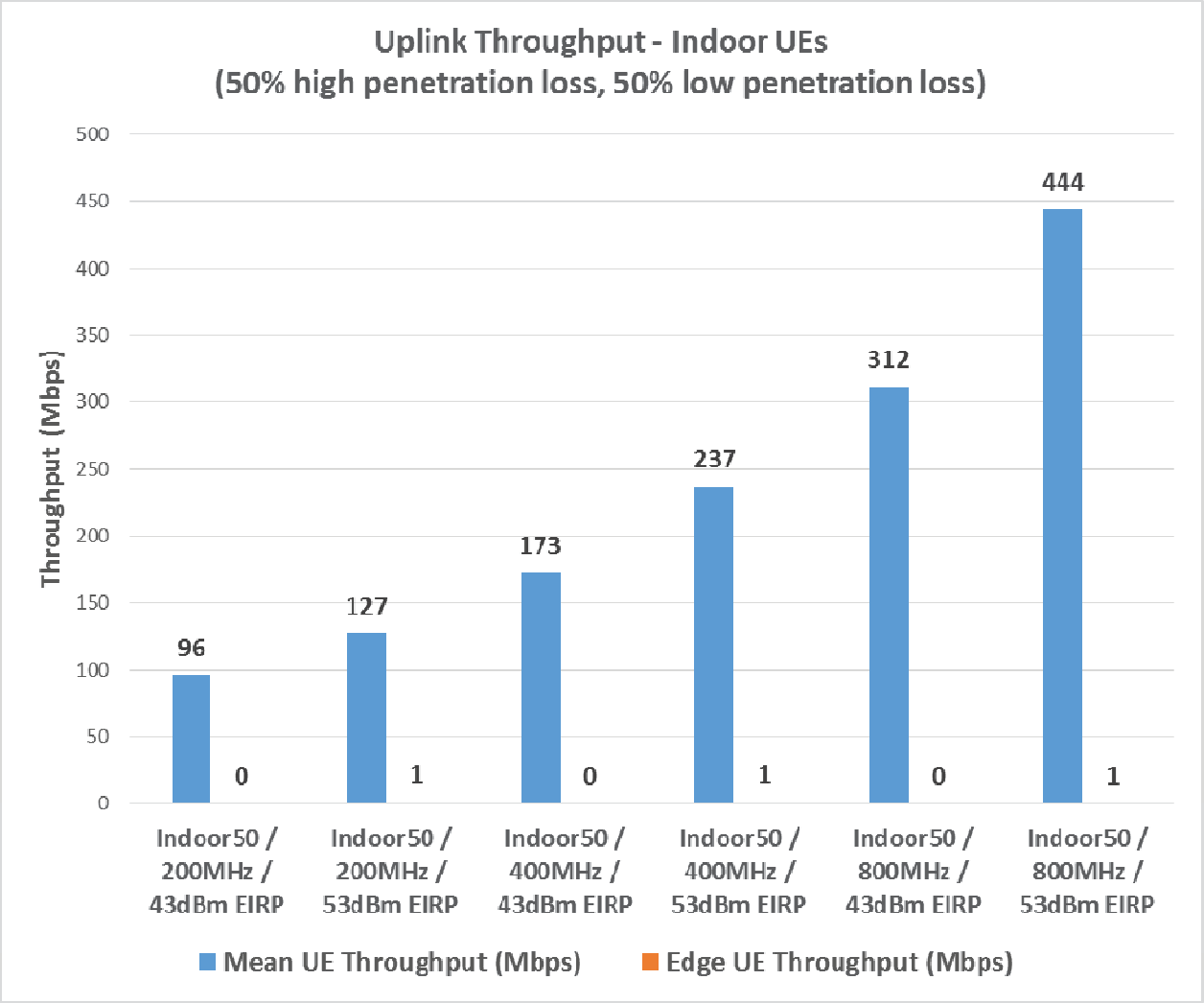

Figure 3 – Uplink Mean and 5th percentile UE throughput performance: 100% Indoor UEs (half with low penetration loss, half with high penetration loss).

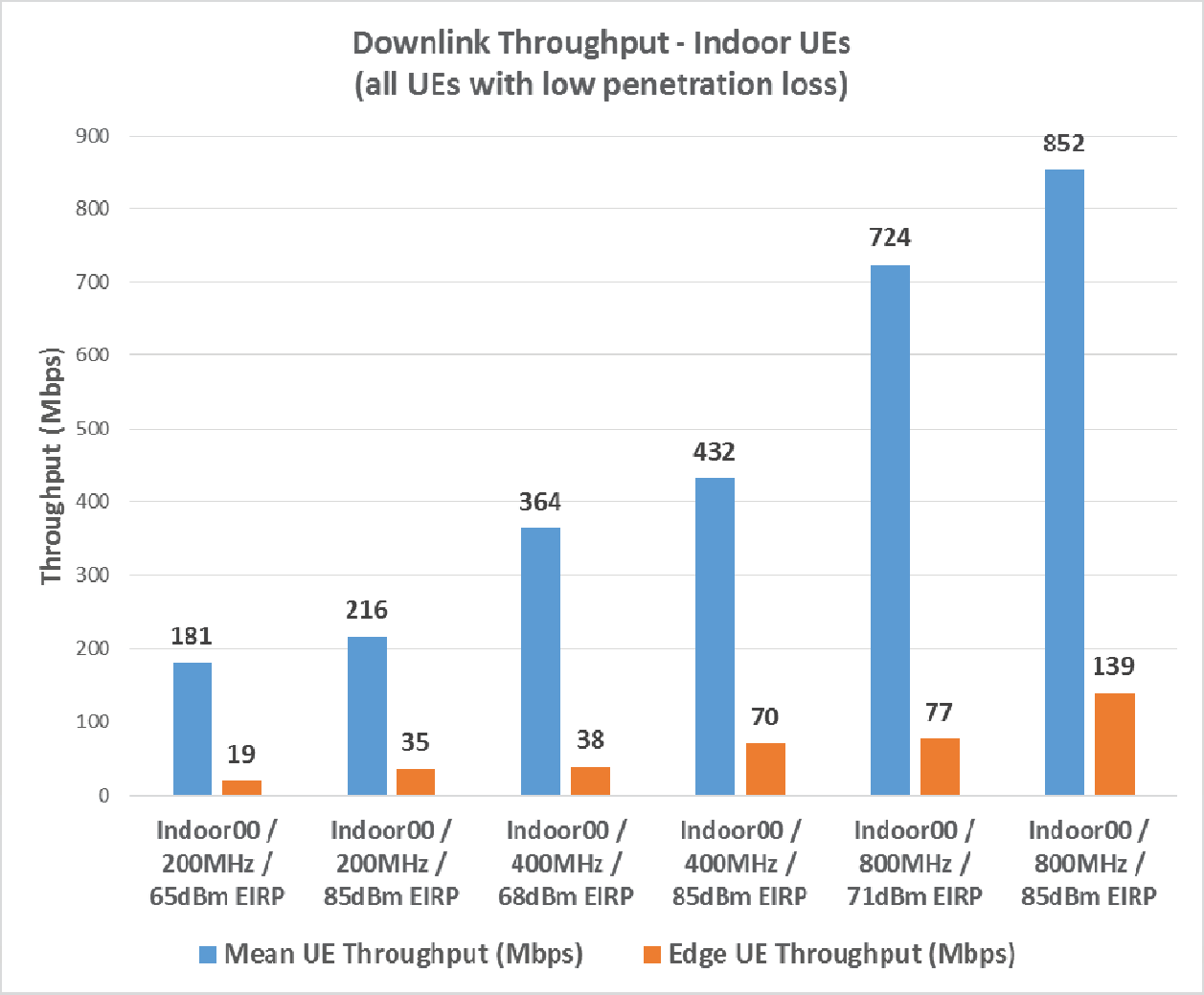

Figure 4 – Downlink Mean and 5th percentile UE throughput performance: 100% Indoor UEs (all with low penetration loss).

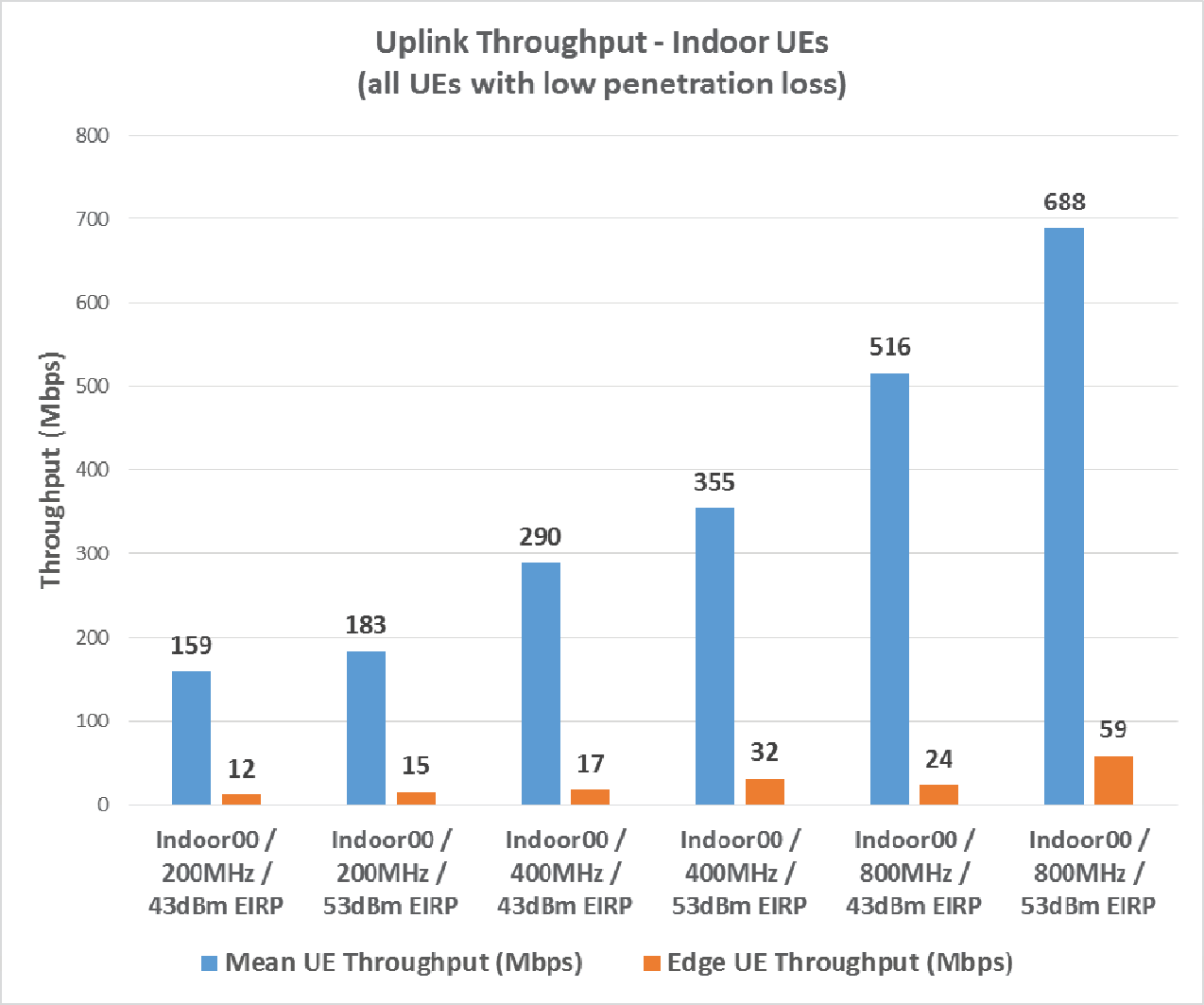

Figure 5 – Uplink Mean and 5th percentile UE throughput performance: 100% Indoor UEs (all with low penetration loss).

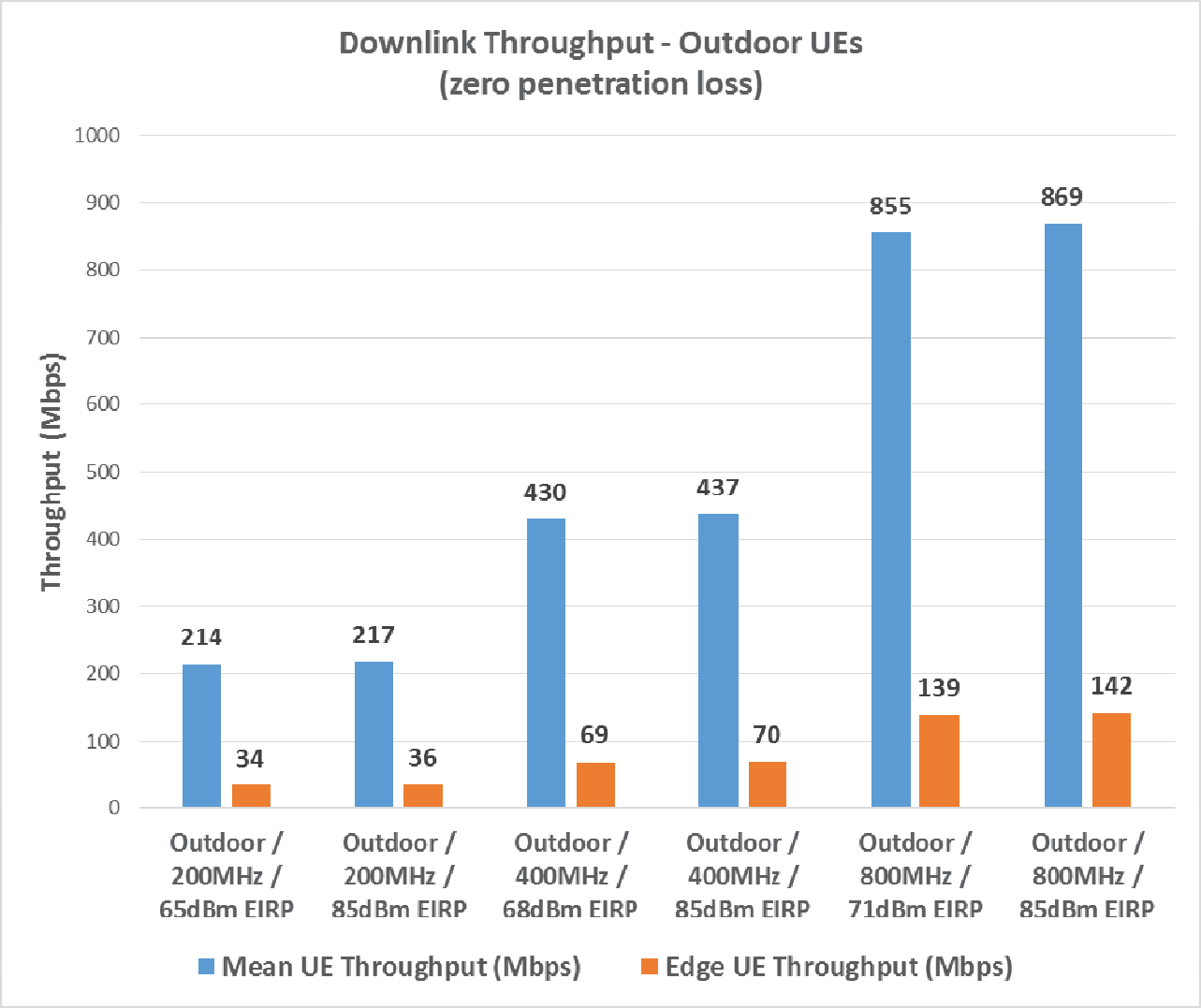

Figure 6 – Downlink Mean and 5th percentile UE throughput performance: 100% Outdoor UEs (zero penetration loss).

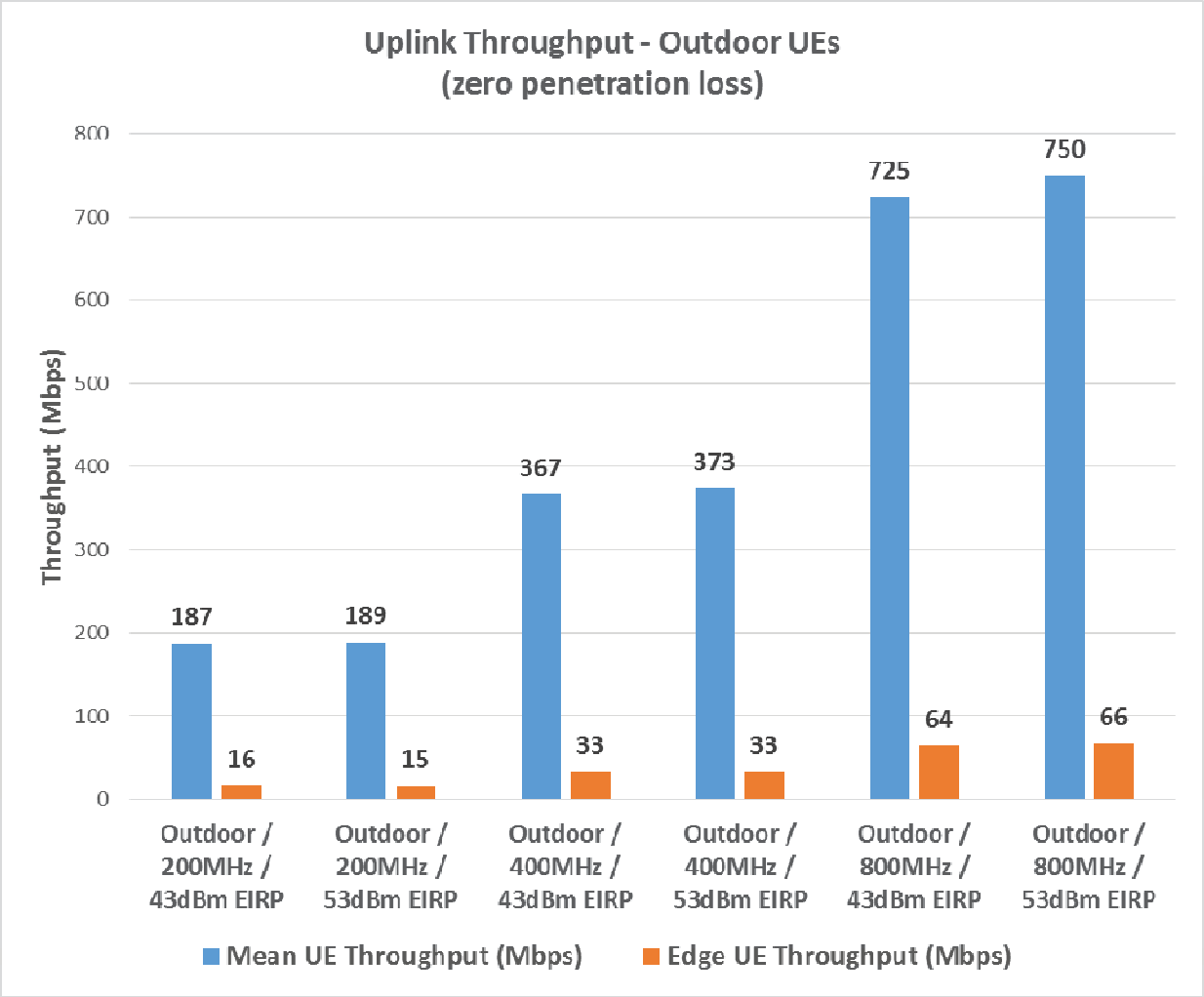

Figure 7 – Uplink Mean and 5th percentile UE throughput performance: 100% Outdoor UEs (zero penetration loss).

D. Throughput and SINR Statistics

This section examines the statistics of two key metrics that are helpful for understanding the performance characteristics of the 5G system. The first metric is the CDF of the received Signal-to-Noise-Ratio (SINR) at the output of the receive antenna processing at the UE, shown in Figure 8. The second metric is the CDF of the per-UE throughput, shown in Figure 9.

The following observations can be made from the results in Figure 8 and Figure 9:

- Increasing the transmit power can provide significant improvements in the SINR and throughput statistics for the indoor UE scenarios. This observation confirms the path-loss limited nature of the deployment under consideration when the UEs are indoors.

- For the outdoor UE scenario, the two downlink EIRP levels provided virtually identical SINR and throughput statistics. This result confirms the interference-limited nature of the deployment under consideration when the UEs are outdoors.

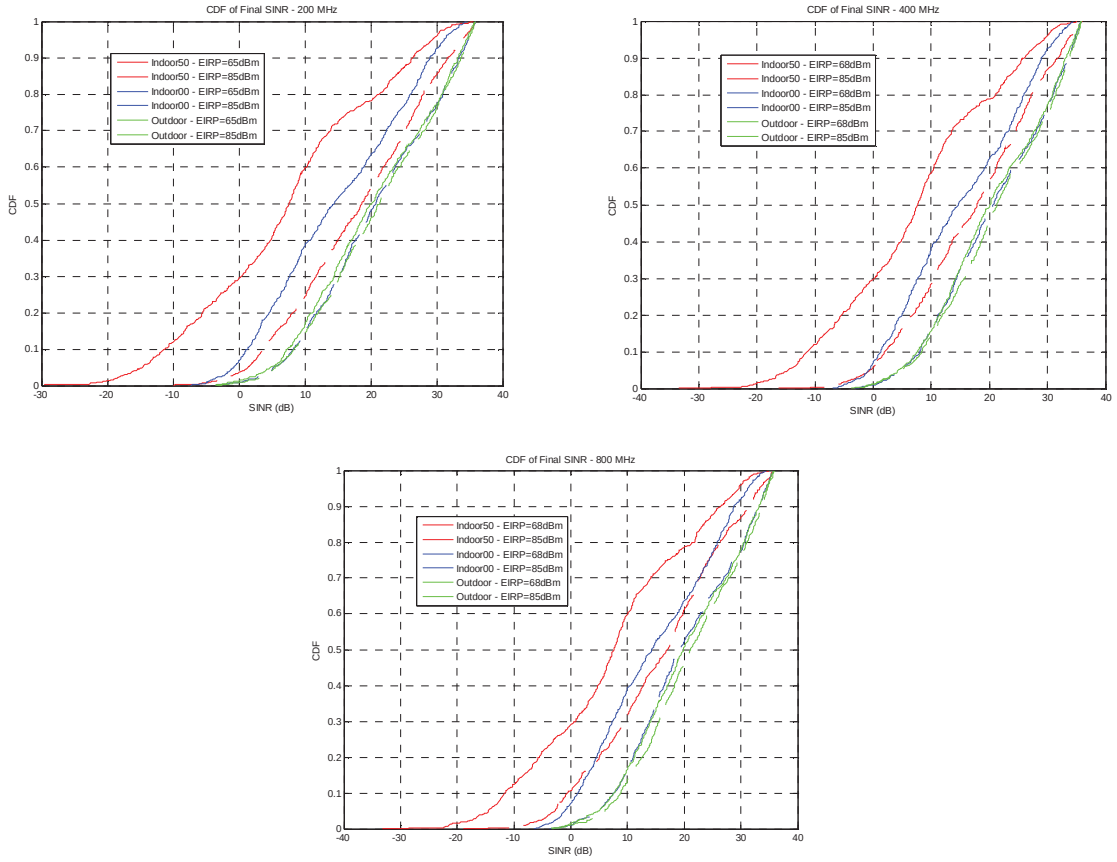

Figure 8 – CDF of post-receiver processing (final) SINR at the UE (downlink) for 200MHz, 400MHz, and 800MHz bandwidths.

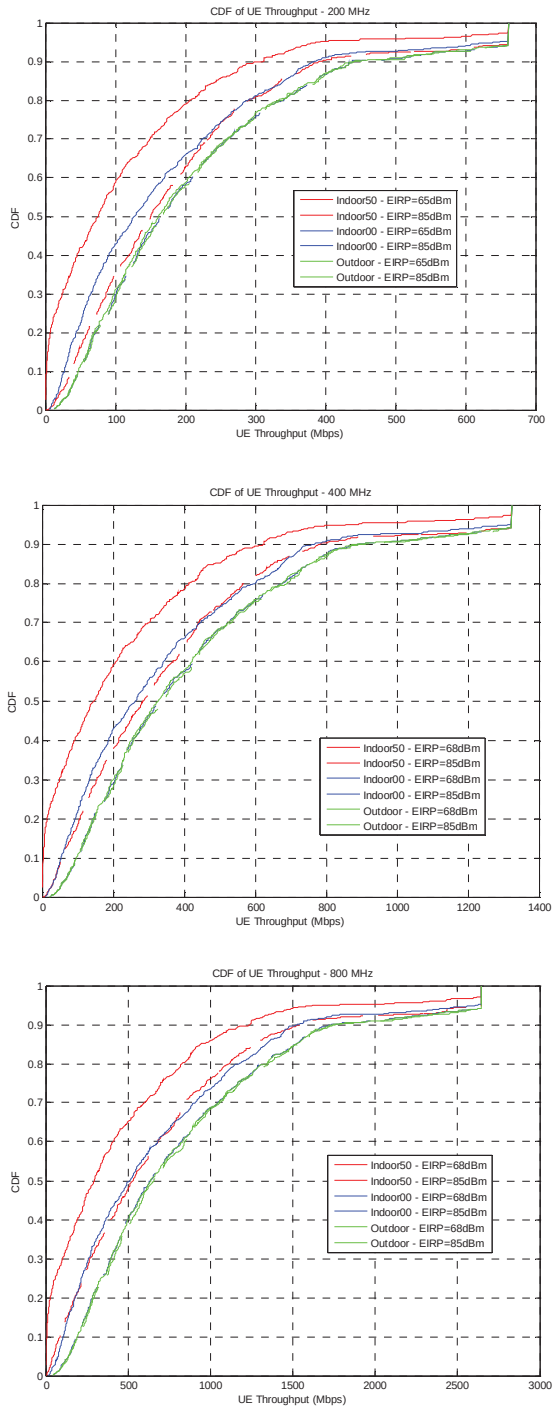

Figure 9– CDF of Downlink UE throughput: 200MHz, 400MHz, 800MHz bandwidths

E. Conclusions

In this appendix, system level simulation results were provided to show the impact on UE throughput performance that results from increasing the transmit power and the system bandwidth. For indoor UEs, the deployment under consideration was heavily path loss limited due to the high penetration losses at 39 GHz. As a result, increasing the transmit power levels can significantly improve system performance. For outdoor UEs, the deployment under consideration was heavily interference limited, as shown by the fact that increasing the transmit power led to no significant improvement in system performance. Whether UEs were indoors or outdoors, significant increases in system performance can be achieved with higher system bandwidths, as expected.

F. References

[1] A. Ghosh, et al., "Millimeter wave enhanced local area systems: A high data rate approach for future wireless networks," IEEE JSAC Special Issue on 5G Cellular, June 2014.

[2] G. R. MacCartney and T. S. Rappaport, "73 GHz millimeter wave propagation measurements for outdoor urban mobile and backhaul communications in New York City," IEEE ICC-2014.

[3] T. A. Thomas, et al., "3D mmWave channel model proposal," IEEE VTC-2014/Fall

[4] T. A. Thomas, F. W. Vook, "System Level Modeling and Performance of an Outdoor mmWave Local Area Access System," IEEE PIMRC-2014